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... for a brighter future

Development of High Quantum Efficiency Photocathodes for the AWA

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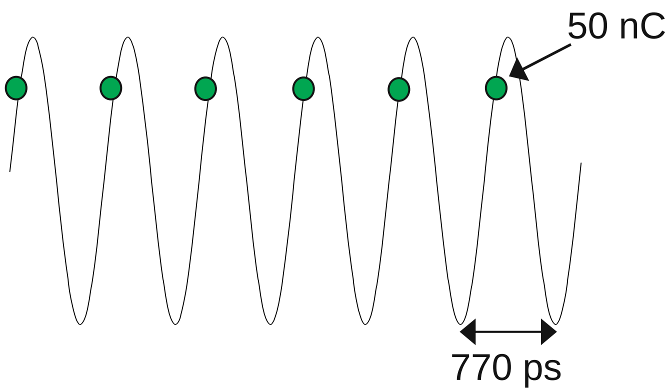
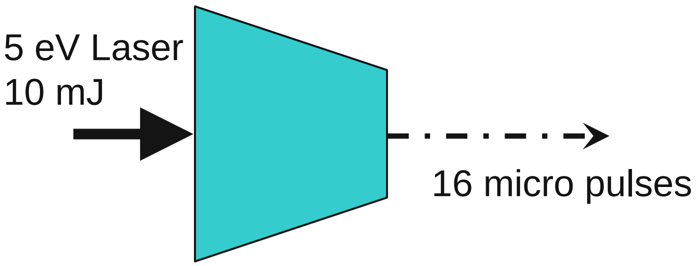
PHOTOCATHODE REQUIREMENT FOR BUNCH TRAIN

For the near future, creation of charge bunch train of 16 bunches in a single RF pulse





Want 50 nC in each charge microbunch. This is equal to ~ 3×10^{11} electrons.

- 10 mJ of laser energy per pulse;
- Estimate 80% loss due to beam splitter, mirrors, etc.;
- Beam is split into 16 micro pulses;
- Number of photons in each micro pulse is ~1.5×10^{14}.

QE of photocathode to be able to supply that amount of charge:

$$QE = \frac{3\times10^{11}}{1.5\times10^{14}} \approx 2\times10^{-3} = 0.2\%$$

Need high QE photocathode – choose Cs_2Te

Cs_2Te RECIPE

- Formulated at LANL;
- Deposit 10-20 nm of Te on Mo substrate;
- Then deposit Cs and monitor QE using light source (typically $h\nu$~5 eV);
- Stop when QE reaches a peak.

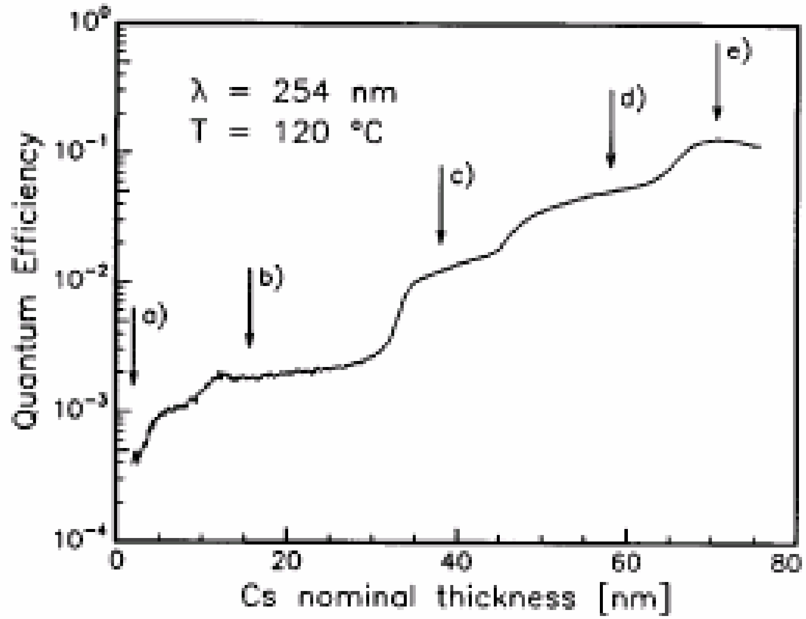
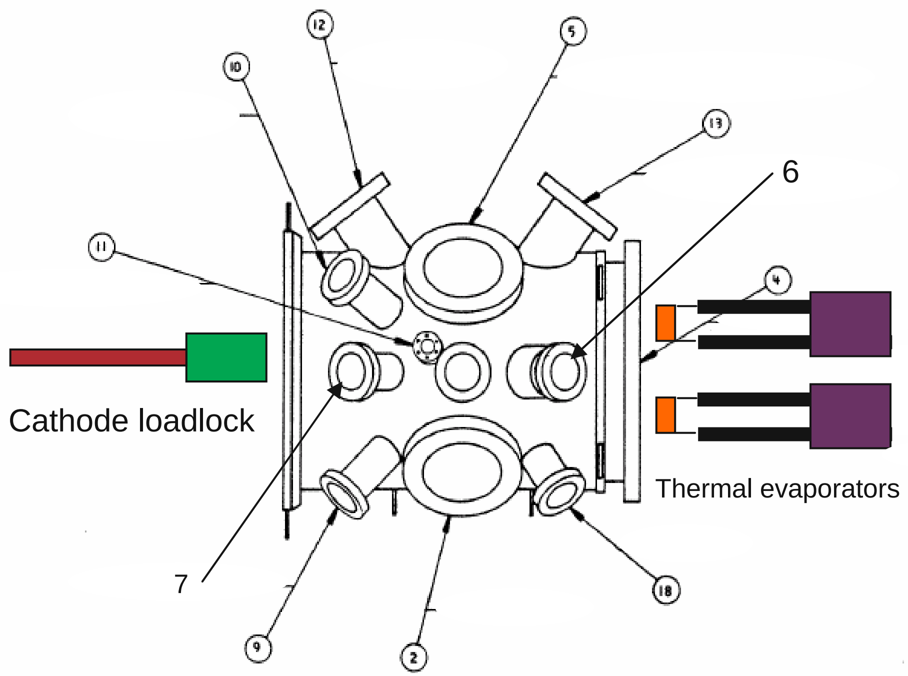


FIG. 1. Quantum efficiency as a function of the Cs nominal thickness during the fabrication of the photocathode. The substrate temperature is held at 120 °C. The arrows indicate the fabrication steps at which XPS experiments have been performed.

di Bona *et al*. J. Appl. Phys. **80**, 3024 (1996)

DEPOSITION FACILITY

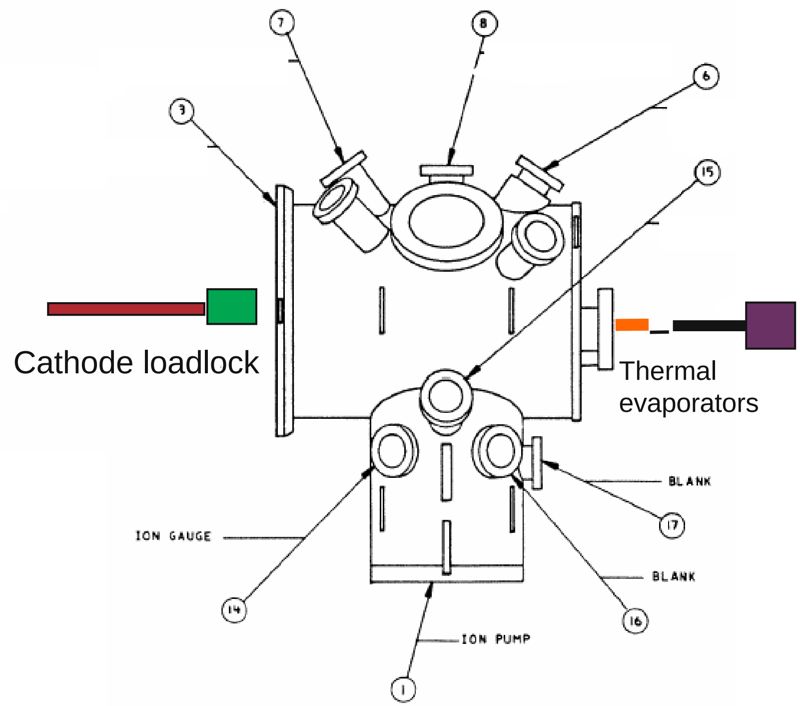
SYSTEM TOP VIEW



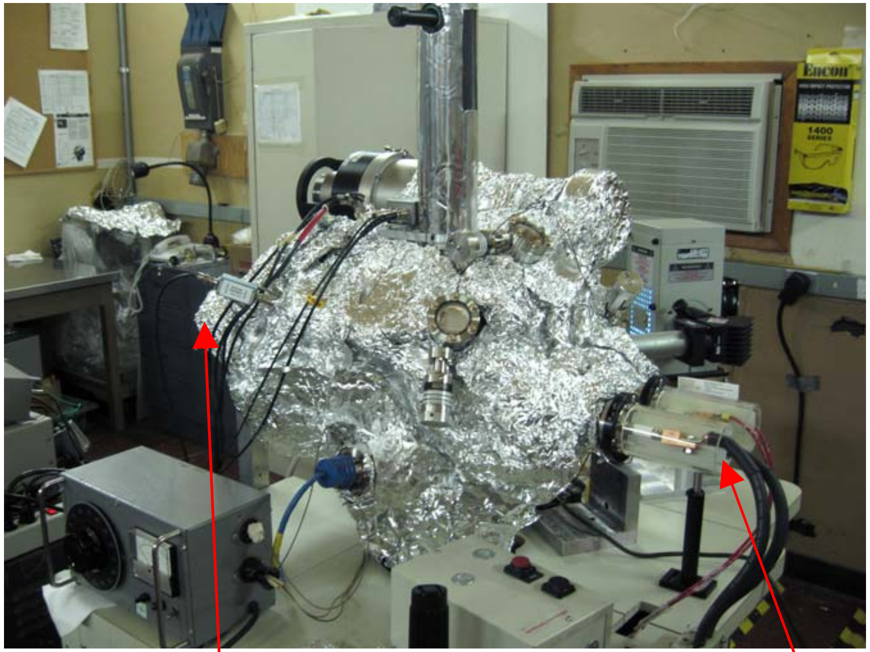
7. Heater/Temp sensor
8. Anode
9. Thickness monitor
13. Hg light source

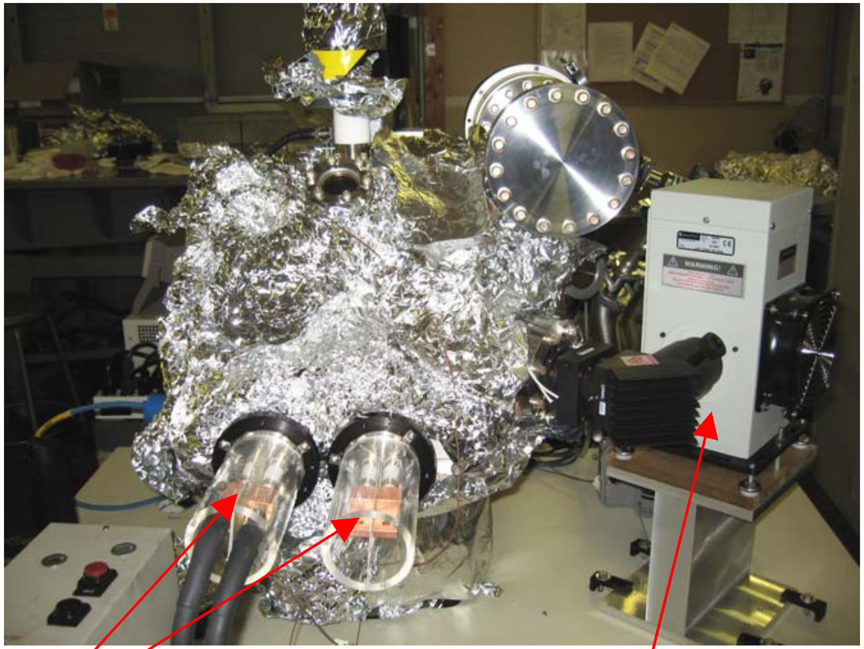
SYSTEM SIDE VIEW

7. Heater/Temp sensor
8. Anode
9. Thickness monitor
13. Hg light source



DEPOSITION FACILITY (cont)





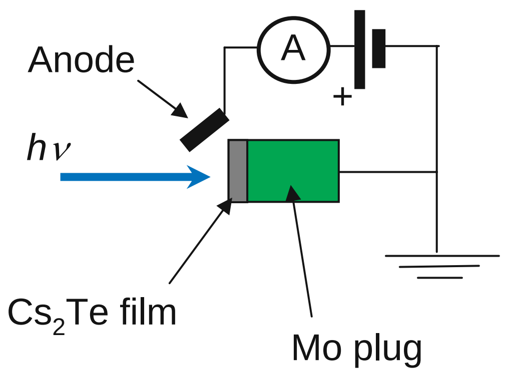
Cathode load-lock transfer will be connected at this end

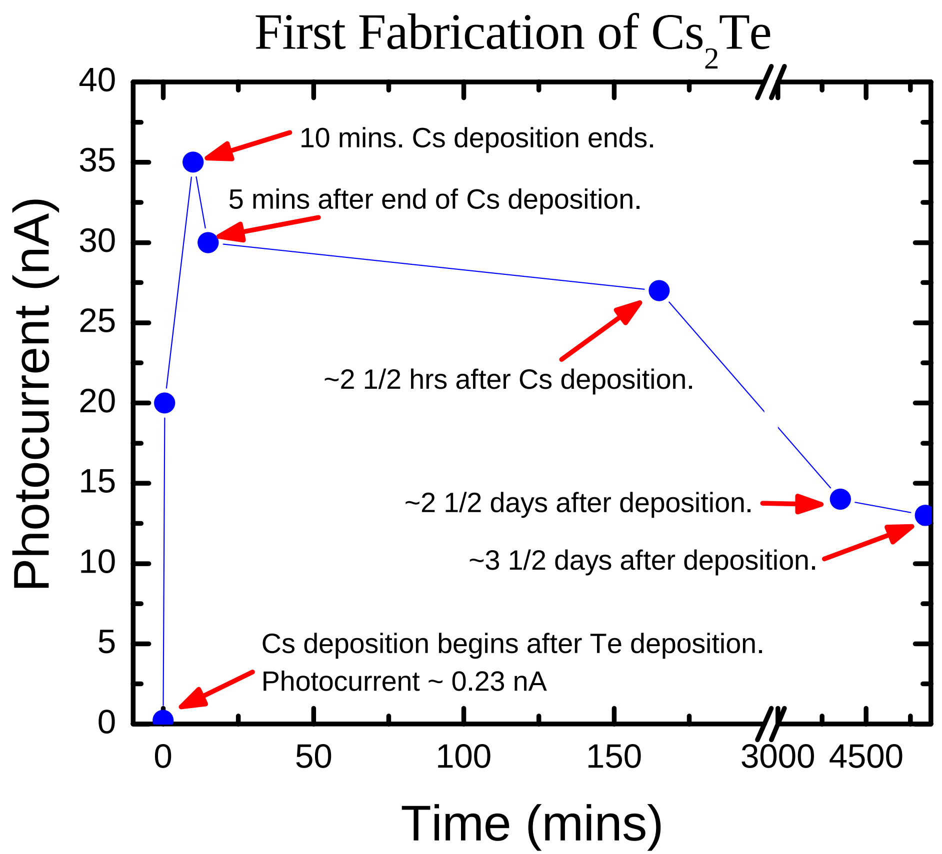
Thermal evaporators

Hg lamp

AT THE 2006 DOE REVIEW - First Fabrication of Cs_2Te

1. Vacuum cleaning and testing had just been completed;
2. First ever deposition was performed to test vacuum pumping rate, thickness monitor, and evaporators;
3. No power meter yet to measure photon flux;
4. Noticed a few observations that were puzzling.





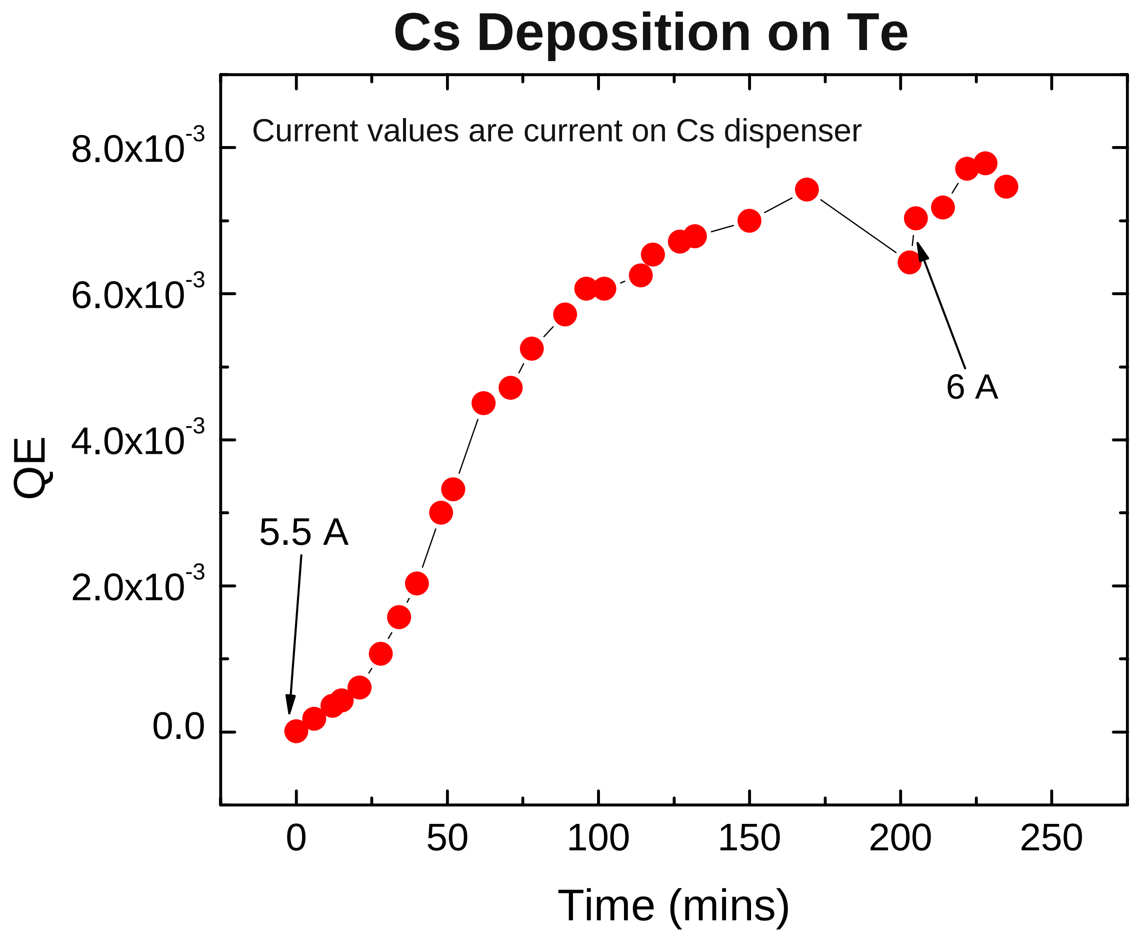
Mo plug temperature maintained at 150 C during deposition. Anode bias potential maintained at 300 VDC. No filters were used on Hg arc lamp during photocurrent measurement.

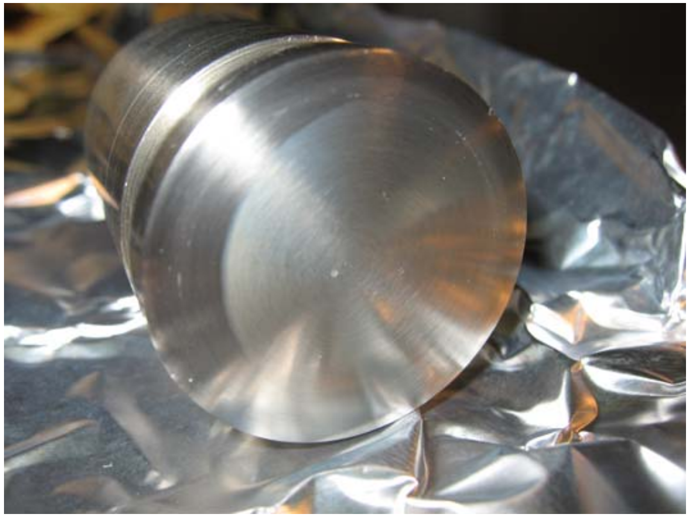
Subsequent measurements put an estimated QE for this to be low 10^{-4}.

MODIFICATIONS, IMPROVEMENTS, AND KNOWLEDGE GINED SINCE FIRST DEPOSITION

- Able to handle the thermionic current from the Cs dispenser;
- Accurate measurement of both photocurrent and photon flux to determine the QE of the cathode;
- Modification to the positions of the Te evaporator and Cs dispenser to improve the quality of the Cs_2Te photocathode;
- Monitored deposition rate, evaporator current settings, etc. are now better known;
- QE has improved by at least 2 orders of magnitude.

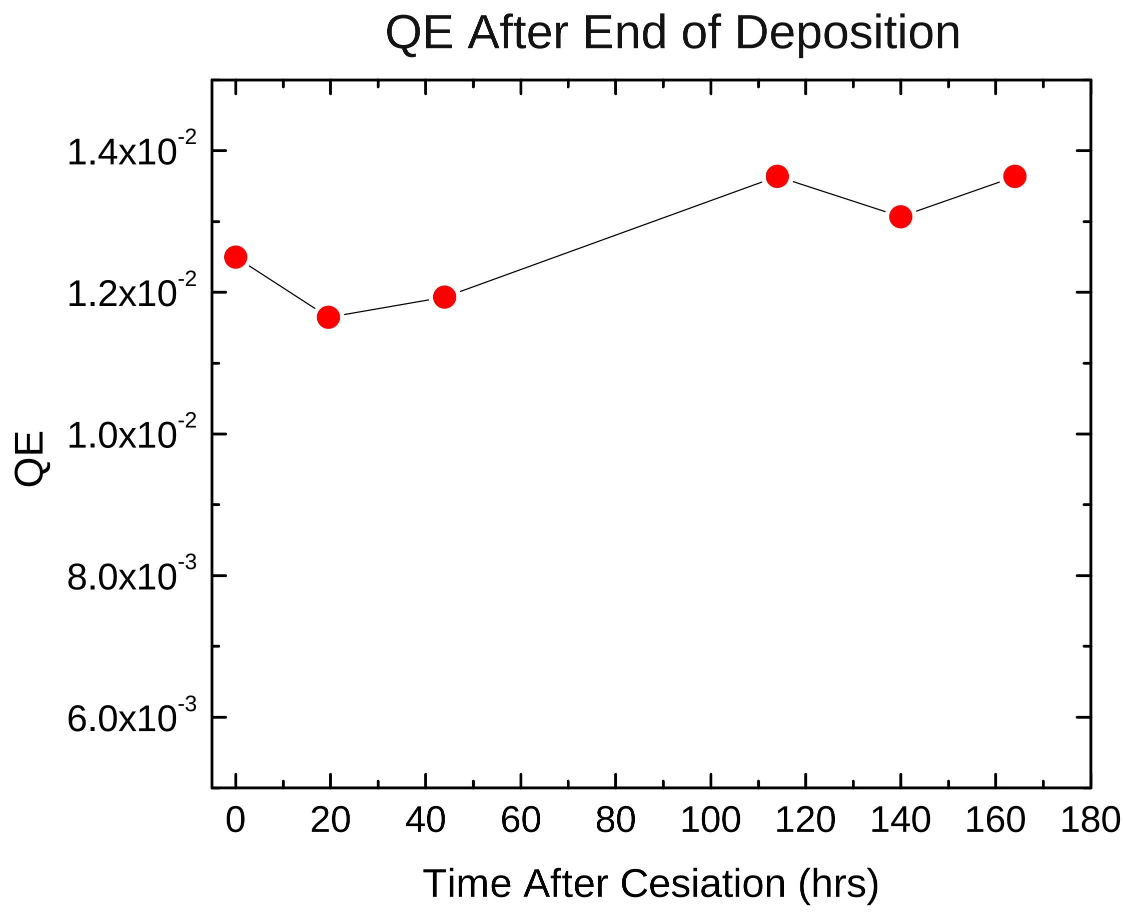
OUR PROGRESS SO FAR





Photocathode shows the bluish/greenish tint that has been reported by other groups. The active photocathode surface is ~ 1 inch in diameter. This surface area is larger than those made at other facilities.

LIFETIME OF QE



- The QE seems to be stable at ~1.3 $\times 10^{-2}$ over 6 days.
- QE is within the required operating value for generating the planned bunch-train experiment.
- There is still a considerable non-uniformity of QE over the surface (~50% variation);
- Still need to do this several times to ensure reproducibility.

SUMMARY AND FURTHER WORK

- QE on Cs_2Te photocathode in within the needed operational value for the planned AWA 16-bunch train experiment;
- The high QE appears to be sustainabled over 6 days;

- Cathode load-lock system to transfer Cs_2Te cathode out of the vacuum chamber has been designed and constructed. This design will be incorporated into the new RF gun;
- Further efforts on improving the QE of the photocathode will be attempted, especially on improving the uniformity over the whole cathode surface;
- More deposition will be made to ensure reproducibility of the high QE;
- The lifetime of the high QE will be studied over a longer period of time.